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Short communication

The effect of bereavement on cognitive functioning among elderly people: Evidence from Australia☆

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ABSTRACT

This paper explores the effects of experiencing the death of a spouse, relative or close friend on cognitive functioning of Australian elderly. Using rich longitudinal data, we show that experiencing a loss is associated with a modest decline in cognitive function. Our results show that on average the effects are more pronounced for males and the strongest effects are associated with the loss of the spouse or a close friend. These events have significant effects on working memory and speed of information processing. We show that the decrease in cognitive functioning is accompanied by decreases in engagement in cognitive activities and declines in socialization. Our results are suggestive that programmes to support grieving individuals, including support for socialization activities, and extending active aging programmes could be important for promoting successful cognitive aging for the growing population of older adults.

1. . Introduction

Losing someone you care about has been considered the most stressful and emotionally devastating event an individual can experience in their lifetime (Holmes and Rahe, 1967). Throughout increased stress and depressive episodes, grief following the loss might have substantial impacts on an individual's mental health and physical health (Stroebe et al., 2007; Galatzer-Levy and Bonanno, 2012). This inevitable event can also change an individual's socialization, daily routines and activities. Although there has been a great deal of research on the effects of depression on cognitive functioning (Gotlib et al., 1998), questions about how bereavement is associated with cognition in older adults and what cognitive dimensions are more affected remain largely unanswered. Existing studies mainly focus on cross-sectional variations in cognitive functioning across populations by comparing bereaved and non-bereaved older adults or focusing on a particular type of bereavement, such as spousal bereavement (Aartsen et al., 2005; van Gelder et al., 2006). Hence, either their scopes are limited and/or their findings are subject to issues related to unobserved individual heterogeneity. Importantly, these studies examine the memory cognitive domain only and overlook dimensions related to 'crystallized intelligence' due to lack of data. While specific dimensions of cognition, particularly applied to 'fluid intelligence', such as episodic memory, abstract reasoning and information processing speed, generally are in decline, other dimensions related to 'crystallized intelligence', such as the ability to draw on experiences, knowledge, skills acquired through socialization, have been found to remain stable into old age (McArdle et al., 2002). Hence it is of interest to examine the association between bereavement (which potentially impact individual's social interactions) and crystallized intelligence.

We contribute to the existing literature by examining the within-person change in cognitive functioning and the experience of bereavement using rich set of Australian longitudinal data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey. These data allow us to examine measures of both fluid and crystallized cognitive abilities, thus providing new evidence regarding the effects of adverse life events on different cognitive domains. In the HILDA Survey, cognitive functioning was measured at two points in time: in 2012 and 2016. This allows us to estimate the change in cognitive functioning associated with bereavement and to account for the unobserved heterogeneity. The data also allow us to examine different types of bereavement, e.g., the death of a spouse/children, relative or close friend. Furthermore, we

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Table 1
Summary statistics.

	Male				Female			
	2012		2016		2012		2016	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Word Reading	15.39	[5.43]	15.25	[5.54]	15.29	[5.25]	15.29	[5.24]
Working Memory	4.83	[1.40]	4.73	[1.33]	4.88	[1.40]	4.83	[1.35]
Speed of Processing	39.03	[10.37]	36.65	[10.73]	41.48	[10.39]	39.75	[10.68]
Age	68.94	[6.28]	72.93	[6.28]	68.28	[5.88]	72.26	[5.88]
Years in education	12.21	[2.38]	12.22	[2.38]	11.46	[2.38]	11.46	[2.38]
Lower education level	0.34	[0.47]	0.34	[0.47]	0.57	[0.49]	0.57	[0.50]
Employed	0.38	[0.49]	0.24	[0.43]	0.25	[0.44]	0.13	[0.34]
Home Ownership	0.90	[0.30]	0.91	[0.29]	0.91	[0.28]	0.91	[0.29]
Living with children	0.15	[0.36]	0.13	[0.33]	0.11	[0.32]	0.1	[0.30]
Age Difference btw partners	4.56	[3.71]	4.58	[3.72]	3.23	[3.09]	3.24	[3.10]
Weekly Frequent Cognitive Activities (0–8)[a]	2.84	[1.23]	2.76	[1.24]	3.32	[1.30]	3.55	[1.34]
Feeling Lonely (1–7)[b]	2.05	[1.52]	2.13	[1.56]	2.29	[1.72]	2.28	[1.72]
Socially Active [c]	0.71	[0.45]	0.73	[0.45]	0.77	[0.42]	0.76	[0.43]
Active Club Member[d]	0.47	[0.50]	0.47	[0.50]	0.48	[0.50]	0.49	[0.50]
	Experienced Life-event between 2012 and 2016							
Death of Spouse		0.03	[0.17]			0.06	[0.25]	
Death of Close Relative		0.35	[0.47]			0.39	[0.49]	
Death of Close Friend		0.50	[0.50]			0.51	[0.50]	
Loss of Spouse/Relative /Friend		0.67	[0.47]			0.69	[0.46]	
Observation	842				751			

Notes: The sample includes individuals who are aged 65 and over and are partnered in 2012. Brackets include standard deviations. (a) Number of cognitive activities reported that are done more than once in a usual week. (Activities include watching TV, reading books; reading magazines; doing puzzles; playing games; writing; arts; going to museums) (b) Question is "How much do you agree or disagree with statement "I often feel very lonely"? The more you agree, the higher the number of the box you should cross. The more you disagree, the lower the number of the box you should cross " (c) This is indicating that individual meets with friends/relatives at least once a week. (d) Currently an active member of a sporting, hobby or community based-club or association.

provide novel evidence on the possible mechanisms through which bereavement could affect an individual's cognitive performance. Specifically, we explore a wide range of mental exercise activities and social behaviours that can potentially drive the cognitive effects of the observed adverse life events.[1] We highlight the differences between men and women in estimated bereavement effects. Few studies in the recent literature focus on the relationship between bereavement and cognition with a gender focus, and the results are inconclusive (Wörn et al., 2020).[2] Finally, our results highlight that establishing the link between bereavement and cognitive functioning is important for public policy. Given that spousal bereavement is associated with an excess risk of mortality (a well-documented phenomenon known as the 'widowhood effect', Sarah et al., 2016), and in light of the recent COVID-19-related death tolls, more substantial preventive policy measures addressing bereavement-induced cognitive declines are needed.

We uncover a substantial heterogeneity in the effect of bereavement on cognitive functioning depending on the loss type and according to the cognitive domains. Experiencing the death of a partner or a close friend was found to have a significant impact on individual's 'fluid intelligence', whereas no effect we observed in individual's 'crystallised ability'. These effects are stronger for males. We also show that the decrease in cognitive functioning is accompanied by decreases in engagement in mental exercise activities and declines in socialization and health behaviours.

2. . Data and summary statistics

The HILDA Survey contains a special module on human capital which includes cognitive assessment tasks. In particular, it measures three dimensions of cognition: (i) pronunciation reading test which is a 25-item version of the National Adult Reading Test (NART25)[3] ; (ii) working memory based on Backwards Digit Span test; and (iii) speed of information processing measured by the Symbol-Digits-Modalities test. These measures cover different aspects of cognitive functioning, namely we use word reading test as a measure of 'crystallized ability' and working memory and speed of information processing as a measure of 'fluid ability'. The tests were administrated in 2012 (wave 12) and 2016 (wave 16). To facilitate interpretation of the results, we standardize the cognitive measures to a distribution with zero mean and unit variance. Our main independent variable is an indicator of whether an individual has experienced a particular loss within the past calendar year. In the self-reported HILDA Survey, these questions have been included since wave 2 (2002). Respondents were asked whether they lost (i) their spouse or children, (ii) a close family member (other than children and spouse), or (iii) a close friend. We use these responses to construct our indicator variables for bereavement. We also combine all three separate life events in an indicator variable for experiencing any losses.

To analyse the mechanisms behind the cognitive effects of bereavement, we utilise various intensity measures of mental exercise activities, socialising, and physical activity available in the HILDA Survey. For the data on the change in mental exercise activities respondents state how often per week they go to museums, art galleries, or watch TV, do puzzles (such as crosswords or Sudoku) and board games; how often they write letters, reports, or stories and read books, magazines, attend

[1] We thank editor, Professor Susan Averett, and an anonymous referee for their constructive comments that led to significant improvement of the paper. This work was supported by a 2020 SOAR fellowship from the University of Sydney.

[2] Support for the hypothesis that men are relatively more distressed than women by the loss of their spouse is provided in early studies. Stroebe et al., (2001) suggest that men suffer relatively greater health consequences than women. However, Gilbar and Dagan (1995) conclude that women have higher depression rates during bereavement than men.

[3] The NART25 is a reading test of 50 irregularly spelled words, listed roughly in order of difficulty which is intended to provide an estimate of pre-morbid intelligence (See Strauss, 2006).

Table 2
Cognitive functioning and bereavement.

	Males			Females		
	Change in Standardised Test Score of			*Change in Standardised Test Score of*		
	Word Reading Test	Working Memory	Speed Information	Word Reading Test	Working Memory	Speed Information
Experienced Any Loss (Spouse, Relative or Friend)	0.005	−0.135**	−0.076*	−0.033	−0.038	−0.021
	(0.033)	(0.068)	(0.044)	(0.036)	(0.067)	(0.043)
R-squared	0.0002	0.0096	0.0058	0.0011	0.0005	0.0003
Experienced Any Loss (Spouse, Relative or Friend)	0.006	−0.136**	−0.076*	−0.031	−0.042	−0.020
	(0.033)	(0.068)	(0.044)	(0.036)	(0.068)	(0.043)
R-squared	0.0081	0.0098	0.0049	0.0475	0.0077	0.0119
Spousal loss	−0.056	−0.037	−0.246**	−0.078	−0.310**	0.051
	(0.090)	(0.119)	(0.117)	(0.074)	(0.141)	(0.076)
R-squared	0.0001	0.0001	0.0071	0.0008	0.0045	0.0016
Spousal loss	−0.059	−0.035	−0.239**	−0.078	−0.310**	0.051
	(0.093)	(0.122)	(0.114)	(0.075)	(0.141)	(0.076)
R-squared	0.0082	0.0049	0.0080	0.0094	0.0093	0.0047
Close relative loss	0.025	−0.072	0.0089	−0.03	−0.007	−0.029
	(0.032)	(0.063)	(0.043)	(0.034)	(0.067)	(0.043)
R-squared	0.0010	0.0012	0.0001	0.0013	0.0000	0.0010
Close relative loss	0.028	−0.073	0.008	−0.0312	−0.007	−0.029
	(0.032)	(0.063)	(0.043)	(0.034)	(0.067)	(0.043)
R-squared	0.0092	0.0060	0.0012	0.0090	0.0046	0.0037
Close friend loss	−0.017	−0.081	−0.069*	0.0024	−0.017	−0.029
	(0.031)	(0.062)	(0.041)	−0.033	−0.063	−0.041
R-squared	0.0004	0.0018	0.0033	0.0001	0.0000	0.0018
Close friend loss	−0.015	−0.082	−0.071*	−0.001	−0.016	−0.031
	(0.031)	(0.063)	(0.041)	(0.033)	(0.063)	(0.041)
R-squared	0.0084	0.0068	0.0048	0.0411	0.0071	0.0127
Observation	842	842	842	751	751	751

Notes: First Difference results from Eq. 1. The specification includes controls for age, employment status, existence of dependent children in the household, tenure status and indicator whether individual has moved since 2012. Full results are available upon request. Robust standard errors are in parentheses.
* $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$.

educational courses or lectures. We count the number of activities that a person engages per week. We look at the change in the numbers of weekly mental exercise activities. We also consider indicator variables for individuals reporting that they feel lonelier in 2016 compared to 2012, less socially and physically active.[4] For the data on socialising respondents state how often they get together socially with friends/relatives and whether they are active members of community/sport clubs. The variable ‘became less social’ takes value 1 if they reduce their weekly meetings with their friends and relatives. The variable ‘became less active’ takes the value 1 if respondent reports no longer being an active member of community/sport or hobby clubs.

The resulting estimation sample consists of individuals aged 60−85 at the time of their first cognitive interview in 2012 who reported that they were partnered. We further restricted the sample to individuals who either did not change their marital status or became widowed.[5] Our final sample includes 842 women and 751 men assessed at two points in time. Table 1 reports that our male and female sample characteristics are similar, although men are slightly older, more educated and reported to be employed. The word reading test scores on both samples are similar; however, females score higher on the speed of information processing. In the 4-year period between 2012 and 2016, we observe that 69 % of women and 67 % of men either lost their spouse, close friend or relative. Approximately half of our sample loses their close friends during our observation period, and around 30 percent loss their close relatives. The least frequent event is the loss of a spouse.

[4] See Table 1 footnote for exact question.
[5] We exclude individuals who divorced or remarried during the observed period.

3. . Empirical methodology

To investigate whether experiencing a loss of a spouse, close relative, or friend affects the cognitive outcomes of elderly men and women in Australia, we consider the following first difference (FD) model:

$$\Delta C_{it} = \Delta Loss_{it}\beta_1 + \boldsymbol{\Delta X}'_{it}\gamma + \Delta u_{it} \tag{1}$$

where C_{it} denotes individual i's cognitive outcome at time t, and; X_{it} captures time-varying observed explanatory variables including person's age employment status, existence of dependent children in the household, tenure status and indicator whether individual has moved since 2012; Δ denotes the change from one period to the next, i.e. $\Delta C_{it} = C_{it} - C_{i,t-1}$, $\Delta \boldsymbol{X}_{it} = \boldsymbol{X}_{it} - \boldsymbol{X}_{i,t-1}$, and $\Delta u_{it} = u_{it} - u_{i,t-1}$, $\Delta Loss_{it}$ is an indicator dummy that takes a value of 1 if individual experiences a loss between 2012 and 2016. The FD uses the within-person change over time in the predictor variables (e.g., experiencing loss) to predict within-person change in the outcome variable (i.e., cognitive functioning), as result, the time-constant differences between persons are ruled out as confounding variables.[6] It is important to note that FD estimation may not consistently estimate β_1 if time varying unobservables lead to changes in both individual's cognition and cause death of the other person. This issue is particularly concerning while we are examining spousal bereavement given that couples share more

[6] It is plausible that a couple's underlying health risks are correlated, such that, bereavement is more likely to occur for those couples with poor health. This correlation between the health status of a couple is in part due to the assortative matching marriage process (Waldron et al., 1996a,b), where a couple's health is interlinked as they are likely to match with each other on some common characteristics, such as social class, race, education, age and occupation.

Table 3
Propensity Score Difference-in-Differences Estimation Results.

	Males			**Females**		
	Change in Standardised Test Score of			*Change in Standardised Test Score of*		
	Word Reading Test	Working Memory	Speed Information	Word Reading Test	Working Memory	Speed Information
Experienced Any loss	0.014	−0.150*	−0.176**	−0.055	−0.140	−0.057
(Spouse, Relative or Friend)	(0.099)	(0.087)	(0.088)	(0.110)	(0.096)	(0.103)
Spousal Loss	−0.039	−0.062	−0.112	−0.111	−0.070	−0.310
	(0.074)	(0.291)	(0.208)	(0.219)	(0.157)	(0.212)
Close relative loss	0.041	−0.057	−0.121	−0.046	−0.097	0.037
	(0.104)	(0.084)	(0.090)	(0.100)	(0.091)	(0.092)
Close friend loss	−0.044	−0.126	−0.162*	−0.027	−0.053	−0.057
	(0.097)	(0.080)	(0.083)	(0.099)	(0.092)	(0.096)

Notes: Table shows the PSM DiD results with Kernel Propensity Score Matching. Standard errors are bootstrapped. * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$.

unobservable risks – hence common shocks are more plausible. Although in our data, we do not observe common accidents, we cannot rule out this possibility. Therefore, our spousal bereavement results should be interpreted within this limitation.

As an alternative to our FD method, we further consider difference-in-difference (Diff-in-Diff) with kernel propensity score matching (PSM).[7] Heckman et al. (1998) discuss in detail the kernel PSM. Smith and Todd (2005) further highlight the advantages of the PSM- Diff-in-Diff estimators compared to the cross-sectional matching estimators. In the first step of our research design, we use PSM, and then we estimate treatment effects by applying Diff-in-Diff estimators for the matched sample. In summary, the idea behind matching is to compare bereaved individuals with similar non-bereaved individuals. This approach consists of matching 'treated' (i.e., bereaved) with 'untreated' (i.e. non-bereaved) individuals based on their observed pre-treatment characteristics[8], and then comparing their cognitive outcomes. Therefore, in computing the differences underlying the average effect of treatment on the treated, we use only matched untreated individuals, not all untreated individuals. This method is also used by Tseng et al. (2017) and Tseng et al. (2018) in the health economics literature when examining the health and wellbeing impacts of spousal bereavement.[9]

To examine the potential mechanisms that could drive the association between bereavement and cognition, we rely on the same strategy and estimate the FD model by focusing on the role of mental exercise, socialization, and physical activity.

4. . Results

4.1. Main results

Table 2 reports the results for the FD estimator for both males and females. Each row corresponds to separate specifications for the bereavement effect on cognition without and with full controls. As evident from the results, when no controls are included, males and females who experienced any loss during the observed period, exhibited lower levels of cognition than comparable individuals; however, the effect is found significant in some domains only. Other things being equal, working memory and speed of information processing that relates to individual's fluid intelligence, decreases between 0.07 and 0.13 standard deviations for men, and the effect is insignificant for women. Overall, when combining all three bereavement events, on average the bereavement has a negative, but modest effect on cognition, and the rate of cognitive decline is greater for men than women. When we examine the effects separately, the impact of losing a spouse significantly decreases cognitive functioning for both men and women. For men, other things being equal, the speed of information processing decreases by 0.25 standard deviations, and the effect is significant at 5% significance level. We do not find evidence that losing a spouse affects men's working memory and word reading test performance, where the latter relates to their 'crystallised ability'. For women, the effect is found significant in the working memory cognitive domain. Specifically, for women losing their spouse is estimated to cause a decrease of 0.31 standard deviations in the working memory performance. Adding a comprehensive set of controls does not change the magnitude and significance level of the main coefficient of interest.

We do not find evidence that the loss of a close relative affects individual's cognition - for both men and women the effects are insignificant, though, for men, a decline in the speed of information processing is found for those who reported a death of close friend. The association remains significant at 10 % significance level after including full controls.

Overall, our findings indicate a differential effect of the type of bereavement events on cognitive decline, where experiencing the death of a partner associates with the highest impact on cognition. This finding is consistent with the negative differential effects reported in cross sectional evidences by Rosnick et al. (2007) and Comijs et al. (2011), where the authors speculate that these differential effects may be due to the different amount of stress these events generate. Importantly, men are relatively more affected by the bereavement compared to women. We also find that the 'crystallized intelligence' remains unaffected, which confirms the existing knowledge that 'fluid' and 'crystallized' cognition exhibit different development trajectories and differential sensitivity in response to cognitive interventions (Stine-Morrow and Basak, 2011).

In addition, we may expect the differential bereavement effects on cognitive functioning to depend on the length of time of this negative stressor is endured. We show the FD results for the associations between length of time of different bereavement events and cognition. We find stronger impacts of the recent

[7] We thank anonymous referee for their suggestion and insights on this matter.

[8] For the matching we follow Tseng et al. (2017) and use socio-economic characteristics of the individual and their partner in 2012, as well as household and residential information in 2012. These covariates also include age, physical health, education, employment status, whether they have kids, outright or mortgage homeowner and household income. For the residential information, we include postcode level of house prices, LGA level average income and unemployment rates. In Online Appendix Figures A1 and A2 we present the overlap of the distribution of the propensity scores across bereaved and non-bereaved groups for men and women based on experienced any loss. We found the extent of the overlap to be satisfactory.

[9] Tseng et al. (2018) argues that by combining PSM and Diff-in-Diff, the method allows to control for the unobserved factors constant in each group and the unobserved time-varying factors common to both groups. See for similar discussion (Smith and Todd, 2005).

Table 4
Cognitive functioning and beravement - FD estimates with attrition weighted adjustment.

	Males			Females		
	Change in Standardised Test Score of			*Change in Standardised Test Score of*		
	Word Reading Test	Working Memory	Speed Information	Word Reading Test	Working Memory	Speed Information
Any Loss	0.012	−0.139**	−0.059	−0.028	−0.038	0.012
(Spouse, Relative or Friend)	(0.032)	(0.071)	(0.050)	(0.033)	(0.071)	(0.045)
R-squared	0.0097	0.009	0.0038	0.0126	0.0054	0.0025
Spousal Loss	−0.054	−0.098	−0.247**	−0.079	−0.303*	0.079
	(0.091)	(0.133)	(0.114)	(0.066)	(0.159)	(0.081)
R-squared	0.0101	0.0043	0.0055	0.0129	0.0111	0.0029
Close relative loss	0.026	−0.099	0.011	−0.025	0.014	0.003
	(0.032)	(0.065)	(0.047)	(0.034)	(0.073)	(0.047)
R-squared	0.0108	0.0067	0.001	0.0123	0.0049	0.0025
Close friend loss	−0.006	−0.065	−0.065*	0.006	−0.025	−0.008
	(0.030)	(0.066)	(0.040)	(0.032)	(0.067)	(0.044)
R-squared	0.0098	0.0052	0.0039	0.0113	0.0049	0.0021
Observation	842	842	842	751	751	751

Notes: The specification includes controls for age, employment status, existence of dependent children in the household, tenure status and indicator whether individual has moved since 2012. Full results are available upon request. * $p < 0.1$ **$p < 0.05$ *** $p < 0.01$.

bereavement events; however, the estimates are imprecise. We examine the younger age groups (40–60), and found consistent impacts, however the effects are smaller and less significant. We also showed that bereavement effects for men are stronger if the age difference between spouses are smaller (less than 5 years). This might be partly driven by that death of partner might be unexpected in this families. Alternatively, these couples might have a similar taste for social and daily routines and loss would be associated with bigger losses in social capital. Finally, we check the single sample, and show that friend loss and relative loss have significant negative effects on single men's cognitive functions.[10]

4.2. Robustness checks

4.2.1. Difference-in-Differences with kernel propensity score matching

In Table 3 we present the results of the kernel PSM Diff-in-Diff estimators for bereavement events. Our results are broadly consistent with the FD estimation and indicate the negative impact associated with the bereavement. The results from the kernel PSM Diff-in-Diff model show that losing someone is associated with a decrease of 0.18 standard deviations in the speed of information processing for men (compared to 0.08 standard deviations found in the FD). The main difference between the FD and Kernel PSM Diff-in-Diff is that in the latter method we find insignificant impacts of spousal bereavement on cognitive scores for both males and females. It is important to note that spousal bereavement is the least frequent event in our sample – for example, only 2 percent of men experienced this event. This may in part explain the differences we observe between the two models.

4.2.2. Attrition

One potential concern is possible non-random attrition in the HILDA survey between 2012 and 2016. Specifically, our findings might underestimate the effects of loss on cognitive decline if the likelihood of panel attrition associated with the loss is higher for those showing larger loss-associated cognitive decline. It is important to note since we are utilizing FD strategy, even if attrition was not random, if it was due to fixed individual characteristics then the FD estimator remains unbiased. We test whether attrition in any of the three cognitive tests scores is random using the approach of Fitzgerald et al. (1998). This approach is based on the assumption that all determinants of attrition can be controlled for (selection on observables). Specifically, we implement a probit model where our dependent variable takes the value of 1 for individuals who drop out of the sample in 2016 due to non-response in any of the three cognitive functioning dimensions, and zero for individuals who remain in the sample, conditional on the four main independent variables: i) any loss; ii) spousal loss; iii) a close family member loss; iv) close friend.[11]

We then use the inverse of the fitted probability to construct the weights that are used to adjust our main FD models. In Table 4 we present the weighted estimations for the three standardized cognitive outcomes. The results show that inverse probability weighted estimates are numerically similar, and qualitatively identical, to the unweighted estimates; therefore, we acknowledge the attrition is not likely to affect our estimates.

4.3. Mechanisms

Fig. 1 shows the potential mechanisms by which bereavement might influence cognition. Using the FD model, we examine the change in social and cognitive activities of individuals between 2012 and 2016. We are focusing on four outcomes: a) decrease in mental exercise activities; b) feeling lonelier; c) becoming less social; d) becoming less active. Fig. 1 shows the coefficient estimates and 95 % confidence intervals for the loss variables from Eq. 1.[12] There are two important results. The FD results show that men who lost someone are less likely to participate in mental exercise activities and to socialise with friends or become inactive. Though this effect only significant for socialization at 10 % (p-value: 0.052). Holding all other observable factors constant, we observe that for men losing a spouse associates with a 0.29 percentage point decrease in participating in mental exercise activities. For

[10] Results available upon request.

[11] Results reported in Appendix Table A2 correspond to four separate probit models for the bereavement effects on attrition for women and men, respectively. The *Pseudo R-squared* from the attrition models suggest that baseline variables explain between 3 to 7% of cognitive scores attrition between 2012 and 2016, which has a relatively low explanatory power. Variables that significantly predict attrition in cognitive test outcomes include total test cognitive score in 2012, bereavement events, home ownership and presence of children over age of 15. A Wald test of whether these explanatory variables are jointly equal to zero suggests their joint significance in prediction the attrition.

[12] Eq. 1 is modified with new dependent variables. We also use probit regressions and the results are robust.

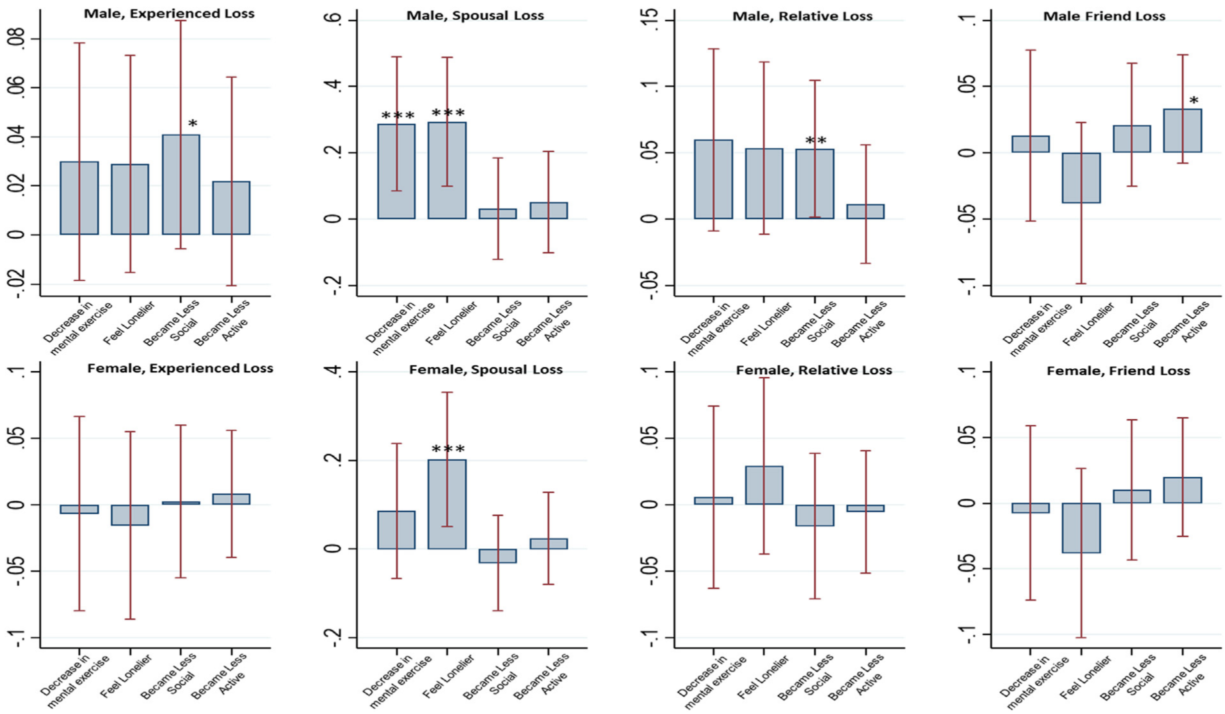

Fig. 1. Potential Mechanisms.

Notes to Fig. 1: First Difference (FD) models with full controls are reported. Figure represents the coefficient estimates and 95 % confidence intervals for "experiencing loss" indicator in Eq. 1. Each bar represents a separate regression. Note that all dependent variables use the change of values from 2012 to 2016. For definitions of dependent variables see footnotes of Table 1. * p < 0.1 **p < 0.05 *** p < 0.01.

both males and females, the loss of a spouse is associated with an increase in feelings of loneliness. However, men reported greater levels of loneliness compared to women. Males also show a decrease in their social engagement due to the bereavement, and this in part explains the negative effect we observe on their cognitive functioning (van Gelder et al., 2006). Overall, our findings are in line with Stroebe et al. (2001) and indicate that men are relatively more affected by the bereavement compared to women. We also examine the impact of the loss on mental health (measured by the SF-36) and overall stress levels; as expected, we observe negative impacts on these measures, we did not observe any significant impact of bereavement on the mental health.

5. . Conclusion

This article presents Australian evidence on the effect of bereavement on cognitive functioning and adds to the literature by providing evidence on the possible mechanisms through which bereavement could influence individual's cognitive performance. Our data enable us to examine both fluid and crystalized cognitive dimensions. We find heterogenous impacts of bereavement on cognitive functioning. Importantly, men are relatively more affected by the bereavement compared to women. We also find that the 'crystallized intelligence' remains unaffected. While we cannot interpret these results as conclusively causal (due to potential time varying unobservables), our finding that the effect is more pronounced on working memory and speed of information processing[13] could be useful in development of intervention programmes for targeting specific dimensions of cognitive decline.

Our findings further indicate that bereavement is associated with decreases in participation in mental exercises and social engagement activities. Many studies have supported these findings that physical activity and socialization are preventive factors for cognitive decline (Read et al., 2020; Evans et al., 2018; Thomas, 2011). For example, 'Active After 55' is a 12 weeks home-based program designed, using elements of behaviour change theory, to enhance functional ability and physical activity (Irvine et al., 2013). Our results are suggestive that similar programmes to assist grieving individuals could be important for promoting successful cognitive aging for the growing population of older adults.

CRediT authorship contribution statement

Kadir Atalay: Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing - original draft. **Anita Staneva:** Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing - original draft.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ehb.2020.100932.

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[13] Indeed, the speed of information processing is generally considered one of the most sensitive measures for early Alzheimer's disease (Comijs et al., 2011).

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